# METHODS AND APPARATUSES FOR TRANSFERRING HEAT FROM MICROELECTRONIC DEVICE MODULES

## TECHNICAL FIELD

[0001] The present invention relates generally to methods and apparatuses for transferring heat from microelectronic device modules.

## BACKGROUND

[0002] In response to end-user demand, the computer industry has continually reduced the size of computer components while increasing the capabilities of the components. As the size of computer components decreases and the computing power of these components increases, it becomes increasingly difficult to transfer heat away from the components at an adequate rate. As a result, some components can overheat and fail. In other cases, the speed and/or other operating parameters of the components can become limited by the inability to reject heat from the components at a rapid enough rate.

[0003] One approach to addressing the foregoing problems has been to use heat transfer devices to accelerate the rate at which heat is rejected from computer components. For example, as shown in Figure 1A, a module assembly 10a in accordance with the prior art can include a printed circuit board 11 which carries two packaged chips 12. Heat spreaders 13 are attached to each side of the printed circuit board 11 proximate to the packaged chips 12. A thermally conductive gap filler 14 is disposed between each heat spreader 13 and the adjacent packaged chip 12. Accordingly, the heat spreaders 13 can provide additional surface area (beyond that of the packaged chips 12 themselves) by which to convectively remove heat from the packaged chips 12. Devices such as those shown in Figure 1A are available from Rambus of Los Altos, California.

[0004] One potential drawback with the device shown in Figure 1A is that the heat spreaders 13 alone may not be adequate to cool the packaged chips 12 at a rapid enough rate. One approach to addressing this potential drawback is to add a finned heat sink to the module assembly 10a. For example, as shown in Figure 1B, a module assembly 10b in accordance with another aspect of the prior art includes two heat sinks 15, one disposed adjacent to each of the heat spreaders 13. The heat spreaders 13 are positioned adjacent to the packaged chips 12 (as indicated by arrows A), the heat sinks 15 are positioned against the heat spreaders 13 (as indicated by arrows B), and a clip 16 is disposed around the module assembly 10b (as indicated by arrow C) to keep the components in close thermal contact with each other.

[0005] One drawback with the module assembly 10b shown in Figure 1B is that the fins of the heat sinks 15 can preclude spacing adjacent module assemblies 10b close to each other and can therefore make it difficult to decrease the size of the computer or other electronic device into which the module assemblies 10 are installed. Another drawback is that the relatively large number of components included in each module assembly 10b can make assembling the module 10b a time consuming process, and can reduce the thermal continuity between one component and the next.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figures 1A-1B illustrate packaged chip module assemblies having heat transfer devices in accordance with the prior art.

[0007] Figure 2 is a partially schematic, isometric exploded illustration of a module assembly having a heat transfer device in accordance with an embodiment of the invention.

[0008] Figure 3 is a partially schematic, cross-sectional illustration of a plurality of module assemblies installed in a computer in accordance with an embodiment of the invention.

[0009] Figures 4A-4D are partially schematic, cross-sectional illustrations of module assemblies having heat transfer devices in accordance with further embodiments of the invention.

## DETAILED DESCRIPTION

### A. Introduction

[0010] The present invention is directed to methods and apparatuses for transferring heat from microelectronic devices, including, but not limited to, packaged memory chips. An apparatus in accordance with one embodiment of the invention includes a first heat transfer portion positioned to face toward a first surface of a computer chip module, and a second heat transfer portion positioned to face toward a second surface of the computer chip module. The second heat transfer portion can face generally opposite from the first heat transfer portion, and at least a part of the first heat transfer portion can be spaced apart from the second heat transfer portion to receive the computer chip module. An intermediate portion can be disposed between the first and second heat transfer portions, and the apparatus can further include first and second heat transfer fins that each extend away from at least one of the first heat transfer portion, the second heat transfer portion, and the intermediate portion. The first heat transfer fin can have a first length, and the second heat transfer fin can have a second length different than the first length. In another aspect of the invention, the heat transfer fins can be integrally formed with at least one of the foregoing portions.

[0011] A computer assembly in accordance with another aspect of the invention includes a support and a first connector carried by the support. The first connector can have a receptacle with a first insertion axis positioned at an acute first angle relative to the support. A second connector carried by the support can have a receptacle with a second insertion axis positioned at an acute second angle relative to the support. The assembly can further include a first module having a first end region spaced apart from the support and being received in the first receptacle. A second module having a second end region spaced apart from

the support can be received in the second receptacle. A first heat sink carried by the first module can have at least one first fin oriented at an acute third angle relative to the support, and a second heat sink carried by the second module can have at least one second fin oriented at an acute fourth angle relative to the support. The at least one second fin can be positioned proximate to the first end region of the first module, with the first end region being interposed between the at least one second fin and the support.

[0012] A method in accordance with another aspect of the invention includes mounting a first connector to a support, the first connector having a receptacle with a first insertion axis positioned at an acute first angle relative to the support. A second connector can be mounted to the support and can have a receptacle with a second insertion axis positioned at an acute second angle relative to the support. The method can further include receiving a first module in the first receptacle, receiving a second module in the second receptacle, positioning a first heat sink in thermal communication with the first module, and positioning a second heat sink in thermal communication with the second module. At least one fin of the second heat sink can be positioned proximate to an end region of the first module, with the end region of the first module being interposed between the at least one second fin and the support.

## B. Apparatuses and Methods in Accordance With Embodiments of the Invention

[0013] Several specific details of the invention are set forth in the following description and in Figures 2-4D to provide a thorough understanding of certain embodiments of the invention. One skilled in the art, however, will understand that the present invention may have additional embodiments, and that other embodiments of the invention may be practiced without several of the specific features explained in the following description.

[0014] Figure 2 is a partially schematic, partially exploded view of a portion of a computer or other electronic device 100 having components cooled in accordance with an embodiment of the invention. In one aspect of this embodiment, the

components can include microelectronic devices 112 mounted to a substrate 111 to form a module 120. In one aspect of this embodiment, the substrate 111 can include a printed circuit board (PCB), and the microelectronic devices 112 can include packaged memory chips. In other embodiments, the substrate 111 can include other structures, and/or the microelectronic devices 112 can have other structures and/or functions. In any of these embodiments, the microelectronic devices 112 can be electrically coupled to contacts 122 for electrical communication with other devices located off the module 120. The module 120 can include a first side 121a facing opposite from a second side 121b. In one aspect of this embodiment, both the first side 121a and the second side 121b can include microelectronic devices 112 or other microelectronic devices. In other embodiments, only a single side 121 of the module 120 can include such devices, as described in greater detail below with reference to Figure 4A. In any of these embodiments, the microelectronic devices 112 can be cooled with an integrally formed, finned heat transfer device, as described in greater detail below.

[0015] In one aspect of an embodiment shown in Figure 2, the module 120 can be cooled with a heat transfer device 130 having a first portion 131a and a second portion 131b. Each of the first and second portions 131a, 131b can have a first region 136a and a second region 136b. The first regions 136a can be separated by a gap 133, and the second regions 136b can be connected with an intermediate portion 131c. The heat transfer device 130 can further include one or more heat transfer fins 132 (two are shown in Figure 2 as a first fin 132a and a second fin 132b). In one aspect of this embodiment, the first fin 132a can have a first length L1, and the second fin 132b can have a second L2 that is different than the first length L1. As will be described in greater detail below with reference to Figure 3, the different lengths of the first and second fins 132a, 132b can provide for an enhanced rate of heat rejection from the module 120, while also allowing adjacent modules 120 to be positioned closely to each other.

[0016] To assemble the heat transfer device 130 with the module 120, the heat transfer device 130 can be positioned over the module 120, as indicated by

arrows E so that the module 120 is received in the gap 133. In one aspect of this embodiment, a thermally conductive paste or other formable, thermally conductive material 114 can be disposed on the outward facing surfaces of the microelectronic devices 112, and/or on the inward facing surfaces of the first and second portions 131a, 131b. The thermally conductive material 114 can increase the rate at which heat is transferred from the microelectronic devices 112 to the first and second portions 131a, 131b. The heat transfer device 130 can be attached to the module 120 with an adhesive, or with mechanical fasteners 135, or with the friction between the surfaces of the microelectronic devices 112 and the first and second portions 131a, 131b.

[0017] In one aspect of the foregoing embodiments, the heat transfer device 130 can include a highly thermally conductive metallic material, such as aluminum or copper. In other embodiments, the heat transfer device 130 can include other metallic or nonmetallic materials that are also highly thermally conductive. In any of these embodiments, the fins 132 can be integrally formed with the other portions of the heat transfer device 130, (e.g., the first, second, and intermediate portions 131a-131c). For example, the entire heat transfer device 130 can be molded as a single piece so as to have no readily separable mechanical connections between its component parts. An advantage of this arrangement is that the heat transfer device 130 can provide a single, continuous and uninterrupted heat conductive path between the microelectronic devices 112 and the environment external to the module 120. A further advantage is that the heat transfer device 130 can be less time consuming to install on the module 120.

[0018] The module 120 can be electrically coupled to the computer 100 before or after the heat transfer device 130 is coupled to the module 120. In one embodiment, the computer 100 includes a chassis 101 (a portion of which is visible in Figure 2) and a support 102 positioned to receive the module 120. The support 102 can include a printed circuit board, (e.g., a motherboard), or another suitable support structure. The support 102 can also include a connector 103 having a receptacle 104 positioned to receive the contacts 122 of the module 120.

In one aspect of this embodiment, the receptacle 104 can have a slot configuration to receive the contacts 122. Accordingly, the module 120 can be inserted into the receptacle 104 along an insertion axis 105, as indicated by arrows F. In one aspect of this embodiment, the insertion axis 105 can be inclined relative to the support 102 at an acute angle G. As described in greater detail below with reference to Figure 3, this arrangement can allow multiple modules 120 to be positioned in close proximity to each other while also allowing heat to be transferred away from the first and second fins 132a, 132b at a relatively high rate.

[0019] Figure 3 is a partially schematic, cross-sectional illustration of the computer 100 with a plurality of module assemblies 110 installed in accordance with an embodiment of the invention. In one aspect of this embodiment, each module assembly 110 can include a module 120 and a heat transfer device 130. Each module assembly 110 can be inserted into a corresponding connector 103 and can accordingly be inclined at the acute angle G relative to the support 102. In one embodiment, angle G can have a value of from about 30 degrees to about 60 degrees relative to the support 102. In a particular aspect of this embodiment, the angle G can have a value of about 45 degrees. In other embodiments, the angle G can have other acute values. In any of the foregoing embodiments, the fins 132a, 132b of one module assembly 110 can extend adjacent to the fins 132a, 132b and an end region 117 of an adjacent module assembly 110. An advantage of this arrangement is that the module assemblies 110 can be installed in close proximity to each other without the fins 132a, 132b of one module assembly 110 interfering with the fins 132a, 132b of its neighbor. Suitable connectors 103 having the foregoing features are available from Molex, Inc. of Lisle, Illinois.

[0020] In one embodiment, the computer 100 can include an adjacent structure 106 positioned proximate to the support 102 and the module assemblies 110. In a particular aspect of this embodiment, the adjacent structure 106 can include a power supply or a portion of the chassis 101. In other embodiments, the adjacent structure 106 can include other components. In any of these embodiments, the

adjacent structure 106 can be spaced apart from the support 102 by a distance D. Accordingly, the fins 132a, 132b can be sized to come close to or touch the adjacent structure 106. In still another aspect of this embodiment, the longer fin 132b is positioned closer to the corresponding connector 103 than is the shorter fin 132a. This arrangement is possible in part because the module assemblies 110 are inclined at the acute angle G relative to the support 102. An advantage of this arrangement is that the longer fin 132b can increase the rate at which heat is transferred away from the module assembly 120. Accordingly, providing the heat sink 130 with fins having different lengths can make increased use of the limited space available between the support 102 and the adjacent structure 106.

[0021] In other embodiments, a computer or other electronic device 100 can carry module assemblies having different arrangements. For example, as shown in Figure 4A, the computer 100 can carry module assemblies 410a, each of which includes microelectronic devices 112 positioned on only one side of a substrate 411. A corresponding heat transfer device 430a of each module assembly 410a can accordingly include a heat transfer portion 431 carrying a plurality of heat transfer fins 432a (three are shown in Figure 4A). In one aspect of this embodiment, the heat transfer device 430a can be releasably attached to the module 420 with a clip 434. In other embodiments, the heat transfer device 430a can be coupled to the module 420 with other devices. In any of these embodiments, the module assemblies 410a can be oriented at an acute angle G relative to the support 102, and the heat transfer fins 432a can extend adjacent to an end region 417 of the neighboring module assembly 410a. Adjacent heat transfer fins 432a can have different lengths to take advantage of the tapered volume between the module 420 and the adjacent structure 106. Accordingly, the module assemblies 410a can be relatively closely spaced while still providing a relatively high rate of heat transfer from the microelectronic devices 112.

[0022] In another embodiment shown in Figure 4B, a computer or other electronic device 100 can support module assemblies 410b having a different arrangement of heat transfer fins 432b. In one aspect of this embodiment, the heat transfer fins

432b can extend generally normal to the support 102 and the adjacent structure 106. In another aspect of this embodiment, the heat transfer fins 432b can be attached to a module 420 that is inclined at an acute angle H having a value less than that of angle G shown in Figure 3. In a particular aspect of this embodiment, the acute angle H can be about 30 degrees. In other embodiments, the acute angle H can have other values. In any of these embodiments, the heat transfer fins 432b can enhance the rate at which heat is removed from the corresponding module 420 without interfering with the heat transfer fins 432b of the adjacent module 420. For example, each module 420 can be generally parallel to its neighbor, and the heat transfer fins 432b of each module assembly 410b can be generally parallel to those of the neighboring module assembly 410b.

[0023] In still another embodiment (shown in Figure 4C) a computer or other electronic device 100 can support a plurality of module assemblies 410c, each inclined at an acute angle G relative to the support 102, and each having a heat transfer device 430c with a single heat transfer fin 432c. In one aspect of this embodiment, the heat transfer fins 432c can also be inclined at the acute angle G. Accordingly, adjacent modules 420c can be generally parallel to each other, and the heat transfer fins 432c of adjacent module assemblies 410c can also be generally parallel to each other as described above. This arrangement can allow close spacing between adjacent module assemblies 410c while permitting enhanced heat transfer from each module assembly 410c.

[0024] In still a further embodiment (shown in Figure 4D) a computer or other electronic device 100 can support module assemblies 420d that do not overlap each other but instead extend generally normal to the support 102 and the adjacent structure 106. Each module assembly 420d can include an integrally formed heat transfer device 430d having heat transfer fins 432d. In one aspect of this embodiment, the heat transfer fins 432d can be oriented at an acute angle J relative to the support 102 and/or the adjacent structure 106. Accordingly, adjacent module assemblies 410d can be generally parallel to each other, and the

heat transfer fins 432d of adjacent module assemblies 410d can also be generally parallel to each other.

[0025] From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the spirit and scope of the invention. Other embodiments of the invention can include the features described above arranged in combinations not explicitly described with reference to Figures 2-4D. Accordingly, the invention is not limited except as by the appended claims.